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Impact of Geographic Location and Social Determinants of Health on Lung Cancer Incidence and Mortality Rates

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IMPACT OF GEOGRAPHIC LOCATION AND SOCIAL DETERMINANTS OF HEALTH ON LUNG CANCER INCIDENCE AND MORTALITY RATES

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By

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I dedicate this thesis to my parents, Don and Diane Ashley, who are a great inspiration to me. I also dedicate this work to all of my friends who have supported me over the past three years and have helped me throughout the process of writing my thesis. Lastly, I dedicate this work to anyone who has been affected by the impacts of lung cancer including patients and their family, friends, and caregivers. Those who have fought against this disease inspire me greatly to contribute to this work.

ABSTRACT

This paper studies the effect of geographic location and socioeconomic status, specifically level of education and income, on rates of incidence and mortality of lung and bronchus cancer. While some prior studies have focused on socioeconomic status' and global geographic location's impact on these rates, few have focused on the impact in Appalachian Kentucky and non-Appalachian Kentucky. In this paper, level of education and income are controlled for using four variables: median household income, percentage of persons in poverty, percentage of high school graduates or higher who are at least 25, and percentage of persons with a bachelor's degree or higher who are at least 25. These four variables are used to determine the socioeconomic status of an individual county in eight-county regions of both an Appalachian and non-Appalachian district. The results suggest that lower socioeconomic status in Appalachian regions is associated with higher rates of incidence and mortality of lung and bronchus cancers. Furthermore, the higher socioeconomic status in a non-Appalachian region is associated with lower rates of incidence and mortality.

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INTRODUCTION

The majority of lung cancers are associated with lifestyle choices like smoking (*Mayo Clinic*, 2019). In addition to lifestyle choices, lung cancers can be attributed to environmental influences like exposure to secondhand smoke, carcinogens, and gases, and they can develop from a family history of the disease (*Mayo Clinic*, 2019). For rates of incidence and mortality of lung and bronchus cancers, a relationship is observed for the highest rates of both of these in the same geographic location. (*USCS Data Visualizations—CDC*, 2017). When observing trends of incidence and mortality of lung and bronchus cancers over the past ten years, there are generally higher rates in the eastern part of Kentucky as opposed to the rest of the state (*USCS Data Visualizations—CDC*, 2017). Cancers of the lung and bronchus are the leading cause of cancer-related deaths in both the United States and in Kentucky. Furthermore, Kentucky has the highest age-adjusted rate of cancer deaths for lung and bronchus cancers when compared to all states (*USCS Data Visualizations*—CDC, 2017).

Prior research has been conducted focusing on the impact of various social determinants of health including socioeconomic status, behavioral choices, and environmental factors on both individual health and population health. These various factors have been studied to determine their impact on increased incidence and mortality rates of lung and bronchus cancers in the Appalachian region of Kentucky. The region of Kentucky designated as Appalachia is set by the Appalachian Regional Commission (ARC) and includes 54 counties in the Eastern region of the state. The ARC reported in

2017 that Appalachian Kentucky's cancer mortality rate was "35% higher than the national rate and 18% higher than the rate in non-Appalachian Kentucky."

Factors related to social determinants of health have been researched to determine their impact on outcomes of lung and bronchus cancer patients in Appalachian Kentucky. Specifically, researchers have focused on lifestyle choices, environmental factors, and public policy to examine various reasons why incidence and mortality rates are historically greater in Appalachian Kentucky as opposed to the rest of the state. This study will examine two social determinants of health specifically, education and economic stability. Due to the disproportionately higher rates of incidence and mortality in Appalachian Kentucky compared to the rest of the state, there is a great need for understanding the correlation between these rates and the potential causes behind the association. By understanding the causes that lead to high incidence and mortality rates of lung and bronchus cancers in this area of Kentucky, efforts could be made through public policy to reduce these rates, which would be vital for the increased health of eastern Kentuckians.

LITERATURE REVIEW

There have been many prior studies done on the persistence of smoking in certain geographical areas and different impacts that have caused this prevalence including studies by Hastert, Beresford, Sheppard, and White in 2015; Rodriguez, Vanderford, Huang, and Vanderpool in 2018; Wilson, Ryerson, Singh, and King in 2016; Schoenberg, Huang, Seshadri, and Tucker in 2015; Islami, Torre, and Jemal in 2015. Previous research conducted on rates of incidence and mortality of lung and bronchus cancers is valuable and continued efforts by public health and medical professionals is needed to decrease rates of lung and bronchus cancers, especially when dealing with behavioral risk factors such as smoking. The prior research focuses on three reasons as to why there are greater rates of incidence and mortality in specific geographic regions as opposed to others.

Hastert, Beresford, Sheppard, and White determined in an article from 2015 that higher rates of incidence and mortality are associated with lower socioeconomic status-level geographic locations. Their study focused on the impact of area-level socioeconomic status on disparities and cancer outcomes in Washington, USA. Through the VITamins and Lifestyle (VITAL) study, and the researchers evaluated how SES, specifically education and household income, impacted risk of prostate, lung, and colorectal cancers incidence and mortality. The conclusions drawn from the researchers' work determined that in the lowest SES-level areas increased rates of incidence and mortality were observed for lung cancers. Moreover, Schoenberg, Huang, Seshadri, and

Tucker examined trends in cigarette smoking and obesity in Appalachian Kentucky through survey data from the Behavioral Risk Factor Surveillance System (2015). The researchers found that low socioeconomic status and impeded access to health care contributed to the perpetuation of the higher prevalence of smoking in Appalachian Kentucky that leads to higher incidence and mortality rates of lung cancer in the region.

Prior research has also attributed higher rates of incidence and mortality to interactions with individuals, their family and peers, and community policies. Rodriguez, Vanderford, Huang, and Vanderpool (2018) evaluated a range of socioeconomic, behavioral, environmental, and policy influences through an adapted version of McLeroy's Social-Ecological Model (SEM) that result in numerous disparities in Kentucky which that were attributed to the high rates of cancer, specifically lung colorectal, cervical, and head and neck cancers in the state. The Social-Ecological Model examines interactions between individuals, their family and peers, and community policies at all levels and is used to determine the impact that those interactions have on an individual's health and any disparities that result from their situation. The researchers' analysis revealed that there was a 56% difference between lung cancer incidence rates and a 57% difference between lung cancer mortality rates in Kentucky as opposed to the United States. Additionally, analysis showed that residents of the 54-county Appalachian region in Kentucky had 5-year rates of incidence and mortality of lung cancer that were greater than residents of the non-Appalachian region of Kentucky due to the interactions observed through McLeroy's SEM.

Most prominently and well-studied, prior research has focused on behavioral risk factors' impact on higher incidence and mortality rates. Wilson, Ryerson, Singh, and

King used data from the National Program of Cancer Registries and Surveillance, Epidemiology, and End Results database to evaluate behavioral risk factors such as smoking in a 2016 study. Wilson and associates determined that high tobacco use contributed greatly to the disproportionately high rates of incidence and mortality in Appalachia. Schoenberg, Huang, Seshadri, and Tucker also examined the impact behavioral risk factors play on incidence and mortality rates in their 2015 research. The researchers found that smoking trends of both men and women consisted of higher rates in Appalachian Kentucky as compared to non-Appalachian Kentucky and the United States due to behavioral risk factors such as smoking. Furthermore, Islami, Torre, and Jemal (2015) examined behavioral risk factors' impact on high incidence and mortality rates of lung cancer through a global lens. The researchers used the World Health Organization GLOBOCAN 2012 database and World Health Organization Mortality database to assess global trends in smoking prevalence and lung cancer mortality. They found that despite measures that have been taken in tobacco control, there will be a persistence of lung cancer being the leading cause of cancer deaths worldwide for several decades due to the continued high prevalence of behavioral risk factors such as smoking in many areas.

METHODS

This study uses data from the Kentucky Cancer Registry to determine rates of incidence and mortality for the Purchase and Cumberland Valley Area Development Districts (ADD) (Kentucky Cancer Registry, 2016). The Kentucky Cancer Registry (KCR) is the official registry of cancer incidence and mortality in the state working with the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program as well as the Centers for Disease Control and Prevention's National Program of Cancer Registries (NPCR). The incidence and mortality rates of lung and bronchus cancers were used to compare the eight county regions of the Purchase and Cumberland Valley ADDs. To account for differences in age distributions of populations, the age-adjusted rates for incidence and mortality were used across all of the sixteen counties that were investigated.

To determine the impact of geographic location has on socioeconomic factors and rates of incidence and mortality of lung cancer, the Purchase and Cumberland Valley ADDs were chosen because both ADDs have similar demographics and populations at-risk of developing lung and bronchus cancers, but all counties in the Cumberland Valley ADD are considered to be in Appalachia by the ARC while all counties in the Purchase ADD are not in Appalachia. Each of these Area Development Districts are composed of eight counties. The Purchase ADD includes Ballard, Calloway, Carlisle, Fulton, Graves, Hickman, Marshall, and McCracken counties while the Cumberland Valley ADD includes Bell, Clay, Harlan, Jackson, Knox, Laurel, Rockcastle, and Whitley counties.

Data for the median household income, percentage of persons in poverty, percentage of high school graduates or higher who are 25 years+, and the percentage of persons with a bachelor's degree or higher who are 25 years+ were obtained from the U.S. Census Bureau's Quick Facts tool to determine the level that social determinants of health impact incidence and mortality rates of lung and bronchus cancers. This tool provides estimates for these four values for 2014 – 2018 based on the 2010 census.

In order to determine the impact that geographic location has on incidence and mortality, statistics for the percentage of high school graduates who are at least 25 and the percentage of individuals with a bachelor's degree or higher who are at least 25 were determined for each county in both the Purchase and Cumberland Valley ADDs from the U.S. Census Bureau's Quick Facts tool. To analyze the two data sets for each Area Development District, the minimum, maximum, mean, and standard deviation from the mean were determined for each population of numbers.

In addition to the statistics used for level of education, the median household income and the percentage of persons living in poverty in each county were used to assess the impact that level of income has on rates of incidence and mortality in an Appalachian county region and non-Appalachian county region. The minimum, maximum, mean, and standard deviation from the mean of these two data sets, the Purchase and Cumberland Valley ADDs, were also calculated.

County level data of each county in the Purchase and Cumberland Valley ADDs was assessed to determine trends in incidence and mortality of lung and bronchus cancers in the Appalachian and non-Appalachian regions. The trends in county level data were observed through visualizations that show data for the Appalachian and non-Appalachian

counties that rank incidence and mortality rates from the maximum to the minimum. Through examining these trends in the individual county data, the validity of the results of analysis is strengthened through observing if certain counties in either the Appalachian or non-Appalachian county regions are outliers to the general trends observed from the initial analysis in Table 1, and are thus masked by the ADD statistics. For each of the four indicators examined, county level data was assessed to determine if there was a correlation in where an individual county ranks within its ADD for a factor and that county's rate of incidence or mortality. Determining trends in where outliers rank in the evaluation of the four indicators allows for discussion on the impact of those factors on the rates of incidence and mortality.

RESULTS

Table 1 contains the results for the analysis of level of education and income across geographic location while comparing incidence and mortality rates. When comparing the rates of incidence and mortality of lung and bronchus cancers in the Purchase and Cumberland Valley ADDs, the average incidence and mortality rates in Purchase ADD are 88.2±32.59 and 63.6±24.65 respectively while the rates in Cumberland Valley ADD are 112.8±17.24 and 78.4±15.66 respectively. These values represent higher rates of incidence and mortality in the Cumberland Valley ADD which includes eight counties that are all part of Appalachian Kentucky.

Table 1 includes the mean and standard deviation of each of the four indicators that were analyzed. The median household income was $41,260.88±$6,271.96 for Purchase ADD which was greater than the median household income for the Cumberland Valley ADD which was $31,341.25±$5,640. In-line with the median household income, there is a greater percentage of people living in poverty in the Cumberland Valley ADD that is in the Appalachian region (28.8±5.9%) as opposed to 18.2±0.06% of people living in poverty in Purchase ADD. When evaluating trends of the median household income for county level data in Figure 4, seven of the eight counties in Purchase ADD had greater median household incomes than all eight counties in the Cumberland Valley ADD. The one county that was in Purchase ADD that did not have a median household income greater than all of the counties in the Cumberland Valley ADD was Fulton County. Figure 6 shows the county level data for the percentage of persons living in

poverty. In observing the trends of this figure, there are two exceptions to the general trend that the counties in the Cumberland Valley ADD have greater percentages of people living in poverty than the Purchase ADD. The two exceptions to this trend are Fulton and Calloway counties.

The percentage of high school graduates or higher who are at least 25 years old in purchase ADD was 84.4±4.6% while in the Cumberland Valley ADD it was 73.8±5.6%. The percentage of individuals with at least a bachelor's degree who are at lease 25 years old is 18.5±5.6% in the Purchase ADD while this value was 12.2±3.3% in the Cumberland Valley ADD. Additionally, when observing trends in the county level data for the percentage of high school graduates or higher seen in Figure 8, six of the eight counties in the Purchase ADD, or non-Appalachian counties, have greater percentages of graduates than counties in the Cumberland Valley ADD. The outliers in this trend are Hickman and Fulton counties, who have lower percentages of high school graduates or higher than two counties that are in the Cumberland Valley ADD, or Appalachian region. Figure 10 shows the county level data for the percentage of persons with a bachelor's degree or higher. In examining the trends in this data, there are two exceptions to the general trend that Purchase ADD counties in the non-Appalachian region have greater percentages of people with a bachelor's degree or higher. Whitley and Laurel counties have greater percentages than some Purchase ADD counties.

Figures 1 and 2 breakdown the analysis of incidence and mortality to the county level. Figure 1 includes the incidence rates of each county in both the Purchase and Cumberland Valley ADDs. There is a pattern observed in this visualization where the majority of Appalachian counties in the Cumberland Valley ADD have higher incidence

rates for lung and bronchus cancers than Purchase ADD counties that are not in Appalachia. The counties that are exceptions to this trend include Carlisle, Ballard, and Calloway counties. Figure 2 follows the same general trend in that the majority of Appalachian counties in Cumberland Valley ADD have higher rates of mortality than Purchase ADD counties with the exception of Ballard, Marshall, and Fulton counties. Hickman and Carlisle counties reported zero deaths that were attributed to lung and bronchus cancers.

DISCUSSION

The values obtained in the results section for level of education and income are representative of a lower socioeconomic status in the Cumberland Valley ADD compared to Purchase ADD. This lower socioeconomic status in the Appalachian Cumberland Valley ADD is correlated with higher incidence and higher mortality of lung and bronchus cancers. The median household income in the non-Appalachian county region is greater, and thus the percentage of persons living in poverty is smaller. In addition, there is a greater percentage of high school graduates and more individuals with bachelor's degrees or higher residing in the non-Appalachian region. This eight-county region has higher levels of income and education indicative of higher socioeconomic status. This region also has fewer new cases of lung and bronchus cancers reported in 2016 and fewer deaths attributed to these types of cancer. The ranges for the median household income, percentage of high school graduates, and percentages of persons with a bachelor's degree in the non-Appalachian county region were all higher than those ranges for the Appalachian county region. The ranges for the percentage of persons in poverty, mortality rates, and incidence rates were all lower for the Purchase ADD as opposed to the Cumberland Valley ADD. These values indicate that the county region with variables that represent lower socioeconomic status had greater rates of lung and bronchus cancers incidence and mortality.

In Figure 1, Carlisle and Ballard counties, which had the highest incidence rates of lung cancer, were both exceptions to the general trend observed where Appalachian

counties have higher incidence rates. Carlisle and Ballard counties had rates of incidence of 157.2 and 103.0 respectively. It is important to note that both of these counties could have a skewed perception of the actual rates of incidence due to their instability. In both counties, less than 15 cases were used to calculate the incidence rate, therefore, the Kentucky Cancer Registry considers those data points to be unstable. Calloway County had an incidence rate that was 11.5 persons per 100,000 greater than that of Clay County which had the lowest incidence rate of the Appalachian counties. Thus, while Calloway County's rate of incidence was an exception, the difference in rates is close and could be attributed to other factors that were not assessed in this study.

In Figure 2, Ballard, Marshall, and Fulton counties had higher mortality rates than expected that did not follow the trend observed in Appalachian and non-Appalachian counties as closely. Ballard County had the highest mortality rate recorded of all sixteen counties at 110.3; however, this county had fewer than 15 deaths that were attributed to lung and bronchus cancer, so therefore this is also an unstable data point in accordance with the Kentucky Cancer Registry. Marshall County had a stable mortality rate of 65.0 which is close in the rates to the two Appalachian counties that had the lowest mortality rates for all of the counties in the Cumberland Valley ADD, so the exception here could be attributed to additional factors that were outside the scope of this study. Fulton County had a mortality rate of 64.5, which again was denoted as unstable due to the small number of deaths attributed to lung cancer in this county during 2016. Additionally, it is important to note that Hickman and Carlisle counties had data points that were suppressed due to fewer than five deaths being attributed to lung and bronchus cancers in 2016.

For the counties that were exceptions to the trend observed that non-Appalachian counties have lower rates of incidence for lung and bronchus cancers, Carlisle and Ballard counties, additional evaluation was done at the county level to determine if those counties reflected an individual county with a lower socioeconomic status than the general non-Appalachian county in the Purchase ADD which was masked in the initial assessment observed in Table 1. Ballard County had an incidence rate of 103.0 and mortality rate of 110.3, which was the highest mortality rates of all counties assessed. Ballard County's median household income was $44,350 which was the third highest value for this indicator of both the Purchase and Cumberland Valley ADDs' counties. 15.3% of persons in Ballard County are living in poverty, which was the third lowest percentage of persons living in poverty of all counties examined in this study. Due to Ballard County having a median household income that is on average higher than other counties in the non-Appalachian Purchase ADD and percentage of persons in poverty that is lower than those counties, it seems that income does not play a factor in the higher incidence and mortality rates in Ballard County.

The percentage of high school graduates or higher who are at least 25 in Ballard County is 85.2%, and the percentage of persons with a bachelor's degree or higher who are at least 25 is 13.3%. For the indicator for the percentage of high school graduates or higher, Ballard County is the fifth highest county of the eight Purchase ADD counties, and for the indicator for percentage of persons with a bachelor's degree or higher, Ballard County has the lowest percentage of all eight counties in its area development district. This implies that there is a correlation between education and the higher than expected incidence and mortality rates in Ballard County, even though it is not in Appalachia. It is

also important to note that Ballard County had unstable data points or both incidence and mortality, so this is another factor that could be influencing the rates of incidence and mortality in this county.

Carlisle County had an incidence rate of 157.2 and mortality rate that was suppressed, meaning fewer than 5 deaths that were attributed to lung and bronchus cancers were reported in 2016. Considering Carlisle County had an unstable incidence rate due to fewer than 15 new cases of lung and bronchus cancers being reported, the data for this county could be skewed due to the small number of cases reported during this year. Additionally, Carlisle County had a median household income of $39,664, which was the seventh lowest value for this indicator of the eight non-Appalachian counties. The county has 17.2% of individuals living in poverty, which was the fourth highest of the non-Appalachian counties. These values indicate that income could play a role in the high incidence rate of Carlisle County, but further evaluation of this socioeconomic factor should be done to determine the strength that this factor has on the incidence rate.

Furthermore, Carlisle County has 81.4% of high school graduates or higher who are at least 25 years old which is the sixth lowest of all Purchase ADD counties, and the percentage of persons with a bachelor's degree or higher who are at least 25 is 14.8% which is also the sixth lowest of these counties. From this data it can be determined that lower education rates than what is typically found in this non-Appalachian county region could display a correlation that is representative of lower socioeconomic status in this county which could play a role in the higher incidence rate; however, further assessment of Carlisle County should be done to determine the impact that these four indicators have in this county when the data is not unstable or suppressed.

Marshall, Fulton, and Ballard counties were three counties that did not follow the general trend observed for non-Appalachian counties in regard to mortality rates. The factors effecting Ballard County were discussed previously when evaluating the incidence rate for the county that was higher than expected. Marshall County had an incidence rate of 83.6 and a mortality rate of 65.0. This county had the greatest median household income of all sixteen counties evaluated at $50,731 as well as the lowest percentage of persons living in poverty of all the counties at 12.1%. These indicators imply that income does not have an impact on the unexpectedly high mortality rate in this non-Appalachian county. Marshall County's percentage of high school graduates was 87.8% which was the third highest percentage of non-Appalachian counties. 18.8% of persons who are at least 25 have a bachelor's degree or higher which is the third highest of the counties in Purchase ADD and the fourth highest of all counties. This data suggests that the indicators used to evaluate education in this study did not have a strong correlation with the higher than excepted mortality rate.

Fulton County had a mortality rate that was outside of the general trend observed for Purchase ADD counties with a rate of 64.5. This rate was considered to be unstable due to fewer than 15 reported deaths attributed to lung cancer in this year. Fulton County also had the lowest median household income of all eight non-Appalachian counties and the thirteenth lowest rate of all sixteen counties with an income of $28,559. This county also has the greatest percentage of persons in poverty of all eight non-Appalachian counties and the fifth highest percentage of all sixteen counties with 30.2% of persons. For the indicators examined for income, there is a correlation between the lower values of this non-Appalachian county and the county's higher mortality rates.

The percentage of high school graduates or higher in Fulton County was 78.2% which was the lowest of all Purchase ADD counties and the tenth lowest of all sixteen counties. Likewise, Fulton County has the second lowest percentage of persons with a bachelor's degree or higher of all Purchase ADD counties and the ninth lowest percentage of all sixteen counties at 13.3%. From the assessment of the indicators for education and income, it is determined that there is a correlation with lower socioeconomic status in Fulton County than the typical trend for Purchase ADD counties. Due to this, and the fact that few deaths were attributed to lung and bronchus cancers during 2016, Fulton County should be assessed further and more indicators incorporated into the study of the county to determine if statistical bias is working to overestimate the impact that these four factors have on the unusually high mortality rate in this non-Appalachian county.

This study examines two social determinants of health (SDOH), education and economic stability. SDOH are defined by the CDC as "the conditions in the places where people live, learn, work, and play that affect a wide range of health risks and outcomes" (Social Determinants of Health, 2018). The ARC published a study by East Tennessee State University and the NORC at the University of Chicago that evaluated the impact social determinants of health and cultural norms play on increased prevalence of tobacco use in Appalachia as opposed to non-Appalachian areas (2019). The ARC determined in their investigation that due to disproportionately high smoking prevalence in the region more frequent tobacco-related diseases occur in Appalachia as opposed to non-Appalachia posing a threat of poorer health outcomes for these individuals. Considering that most all exceptions that were observed for both Figures 1 and 2 were attributed to

unstable data points occurring in those counties in 2016, and that the counties that were considered stable did not tend to have a strong correlation amongst the SDOH that were examined, the general trends that these Appalachian counties have higher incidence and mortality rates of lung and bronchus cancers is upheld. In conjunction with the knowledge that Appalachian counties also have lower socioeconomic factors, it is determined that poorer SDOH that are closely associated with the Appalachian region of Kentucky could have an impact on a person's likelihood to develop lung or bronchus cancer at some point in their lifetime.

CONCLUSION

The goal of this study was to determine the effect that geographic location and social determinants of health like education and socioeconomic status have on incidence and mortality rates of lung and bronchus cancer. The Purchase and Cumberland Valley Area Development Districts were used to test these effects because of Purchase ADD being an eight-county non-Appalachian region and Cumberland Valley beign an eight-county region in Appalachia both of which having similarities in their demographics. It was determined from the results of statistical analysis that the Cumberland Valley ADD had variables that constitute a lower socioeconomic status and level of education attained, thus having higher rates of incidence and mortality while the Purchase ADD had variables that constitue a higher socioeconomic status and education attained, thus having lower rates of incidence and mortality.

A limitation of this study was the inability to determine and examine all social determinants of health that contribute to higher rates of incidence and mortality, and thus poorer health outcomes for Appalachian individuals. There are many background variables like public policy, family history of smoking, and greater prevalence of tobacco farming and marketing that could contribute to the higher rates of incidence and mortality in Appalachia as opposed to non-Appalachia. From this study, it is determined that the two social determinants of health that were examined in this research, education and economic stability, are correlated with higher rates of incidence and mortality of lung and bronchus cancers in the Appalachian ADD as opposed to the ADD that was not in

Appalachia. Further expansion of social determinants of health and their variances across different geographic location could provide beneficial research in the future.

Another limitation to this study includes the time and monetary constraints encountered when working on this project. If the opportunity were available, collection of primary data in both an Appalachian and non-Appalachian county region, rather than the analysis of secondary data, could prove to show greater significance in the results obtained from the study. A challenge was also encountered in rates of incidence and mortality data points which were sometimes considered to be unstable or suppressed due to having fewer than fifteen or five reported new cases or deaths attributed to lung cancer respectively. The counties that were considered to have unstable incidence rates were Carlisle, Ballard, Hickman, and Fulton counties while the counties that were considered to have unstable mortality rates were Ballard, Fulton, and Jackson. These unstable rates of incidence and mortality for these counties thus create a limitation to the study because the data for these five counties could be skewed high or low masking the true value of these data points.

Future research should focus on collecting primary data from these two regions so that the significance could be reassessed. In addition to collecting primary data, future research should aim to test a greater number of social determinants of health. More factors indicate the level of SDOH that an individual has than solely education and income, and in controlling for these variables, more accuracy could be observed in the results.

This work is important for all individuals in Kentucky in order to mitigate the higher incidence and mortality of lung and bronchus cancers as opposed to the rest of the

United States. Continuing this study through increasing the number of social determinants of health examined and strengthening the results could contribute to knowledge in what measures need to be taken across the state, and especially in Appalachia, to decrease rates of incidence and mortality over time contributing to overall improved health in the Appalachian region.

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APPENDIX A: LIST OF TABLES

Table 1 Statistical Data of Factors in Purchase and Cumberland Valley ADDs.

	Minimum	Maximum	Mean	Standard Deviation
Purchase ADD				
Median Household Income	$28,559	$50,731	$41,260.88	$6,271.96
Persons in Poverty	12.1%	30.2%	18.2%	0.06%
High School Graduates or Higher, 25 years+	78.2%	89.8%	84.4%	4.60%
Persons with Bachelor's Degree or Higher, 25 years+	13.3%	29.0%	18.5%	5.60%
Mortality	49.7	110.3	63.6	24.65
Incidence	56.2	157.2	88.2	32.59
Cumberland Valley ADD				
Median Household Income	$24,628	$39,230	$31,341.25	$5,640
Persons in Poverty	20.6%	38.2%	28.8%	5.90%
High School Graduates or Higher, 25 years+	64.3%	81.1%	73.8%	5.60%
Persons with Bachelor's Degree or Higher, 25 years+	8.9%	19.2%	12.2%	3.30%
Mortality	58.4	100.6	78.4	15.66
Incidence	89.1	144.6	112.8	17.24

Table 2 County Level Incidence and Mortality Rates for Purchase and Cumberland Valley ADDs

	Age-Adjusted Incidence	Age-Adjusted Mortality	Population At Risk
Purchase ADD	73.6	54.1	196,175
Ballard	**103.0**	**110.3**	
Calloway	100.6	41.0	
Carlisle	**157.2**	--	
Fulton	**61.8**	**64.5**	
Graves	56.2	49.7	
Hickman	**69.1**	--	
Marshall	83.6	65.0	
McCraken	74.3	51.3	
Cumberland Valley ADD	109.8	79.3	232,811
Bell	101.9	58.4	
Clay	89.1	71.2	
Harlan	108.1	89.6	
Jackson	117.4	**64.2**	
Knox	144.6	97.9	
Laurel	111.3	72.8	
Rockcastle	101.9	72.7	
Whitley	127.8	100.6	
Kentucky	88.2	60.4	4,438,229

*Values in bold indicate unstable data due to fewer than 15 cases being reported
** Rows with "--" indicate the value was suppressed due to fewer than 5 cases being reported

Table 3 County Level Indicators for Education for Puchase and Cumberland Valley ADDs

	High School Graduate or Higher	Bachelor's Degree or Higher
Purchase ADD		
Ballard	85.2%	13.3%
Calloway	89.1%	29.0%
Carlisle	81.4%	14.8%
Fulton	78.2%	13.3%
Graves	85.3%	16.3%
Hickman	78.3%	17.6%
Marshall	87.8%	18.8%
McCraken	89.8%	24.6%
Cumberland Valley ADD		
Bell	69.5%	8.9%
Clay	64.3%	9.5%
Harlan	71.6%	10.8%
Jackson	74.3%	12.2%
Knox	72.3%	13.1%
Laurel	81.1%	13.4%
Rockcastle	77.6%	10.6%
Whitley	79.7%	19.2%
Kentucky	85.7%	23.6%

Table 4 County Level Indicators for Income for Purchase and Cumberland Valley ADDs

	Median Household Income	Persons in Poverty
Purchase ADD		
Ballard	$44,350	15.3%
Calloway	$40,219	21.3%
Carlisle	$39,664	17.2%
Fulton	$28,559	30.2%
Graves	$41,615	16.9%
Hickman	$40,463	17.7%
Marshall	$50,731	12.1%
McCraken	$44,486	14.7%
Cumberland Valley ADD		
Bell	$24,628	31.3%
Clay	$26,250	38.2%
Harlan	$26,324	33.4%
Jackson	$32,143	26.5%
Knox	$28,790	31.9%
Laurel	$39,230	20.6%
Rockcastle	$36,468	22.8%
Whitley	$36,897	25.7%
Kentucky	$48,392	16.9%

APPENDIX B: LIST OF FIGURES

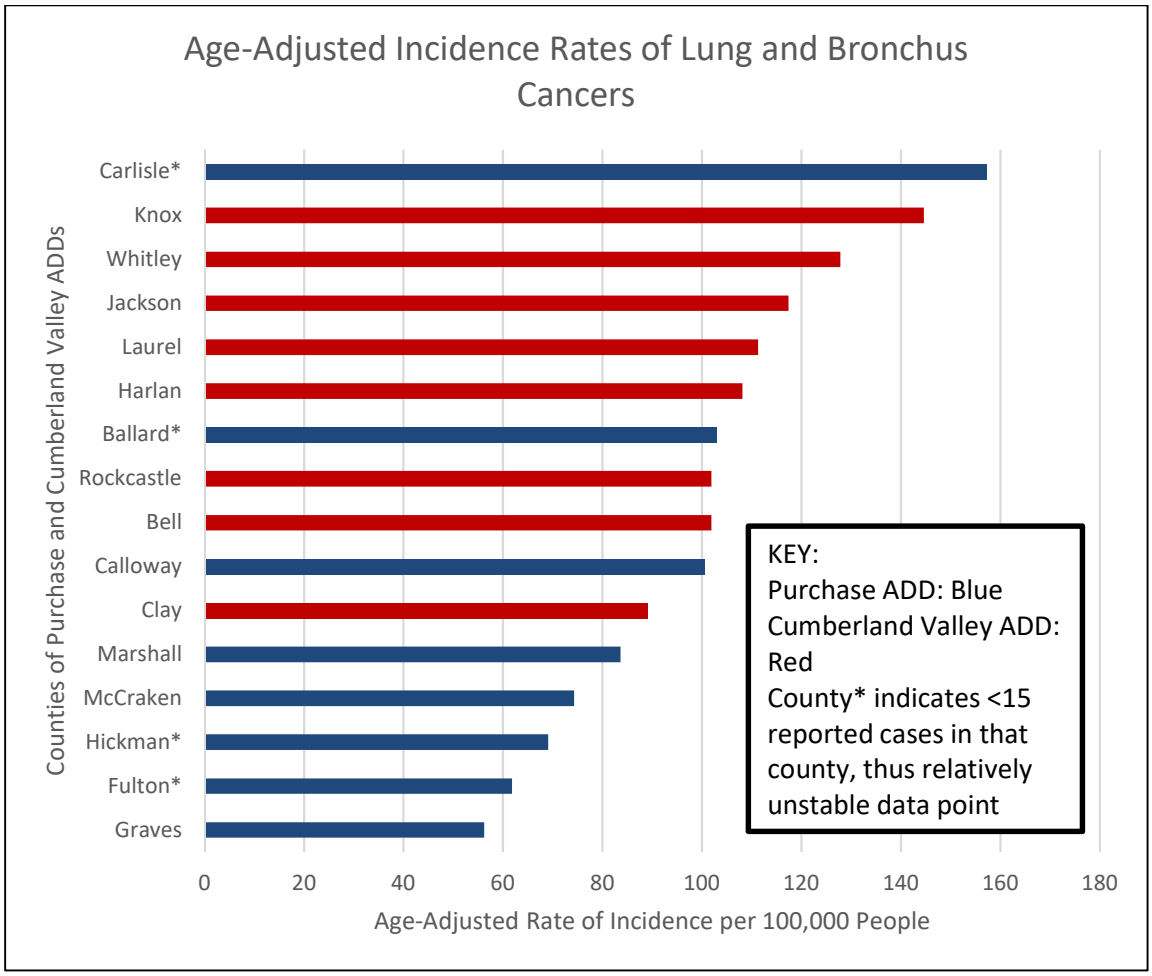

Figure 1 Age-Adjusted Incidence Rates of Lung and Bronchus Cancers for Purchase and Cumberland Valley ADDs

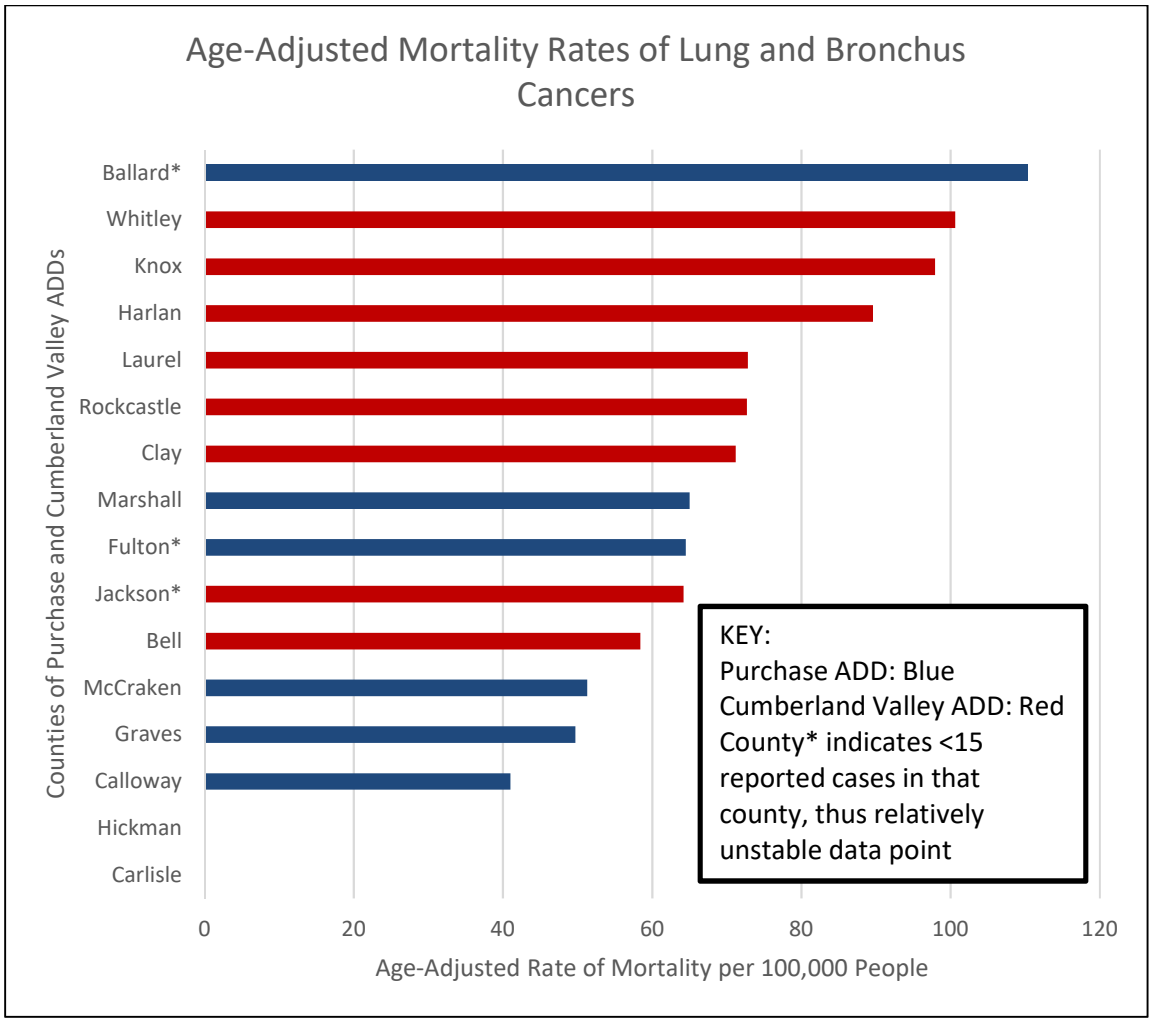

Figure 2 Age-Adjusted Mortality Rates of Lung and Bronchus Cancers for Purchase and Cumberland Valley ADDs

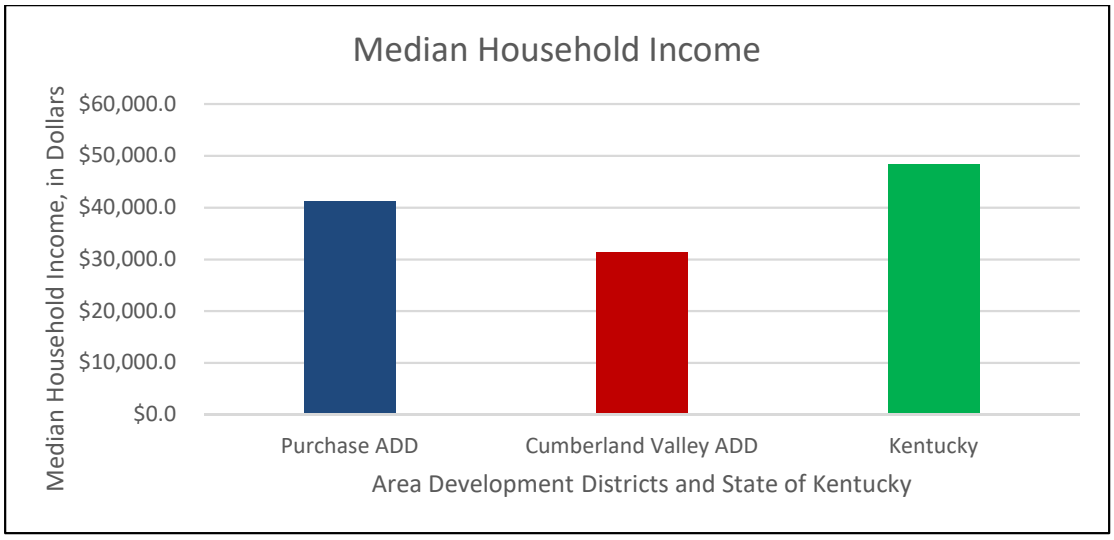

Figure 3 Median Household Income for Purchase ADD, Cumberland Valley ADD, and the State of Kentucky

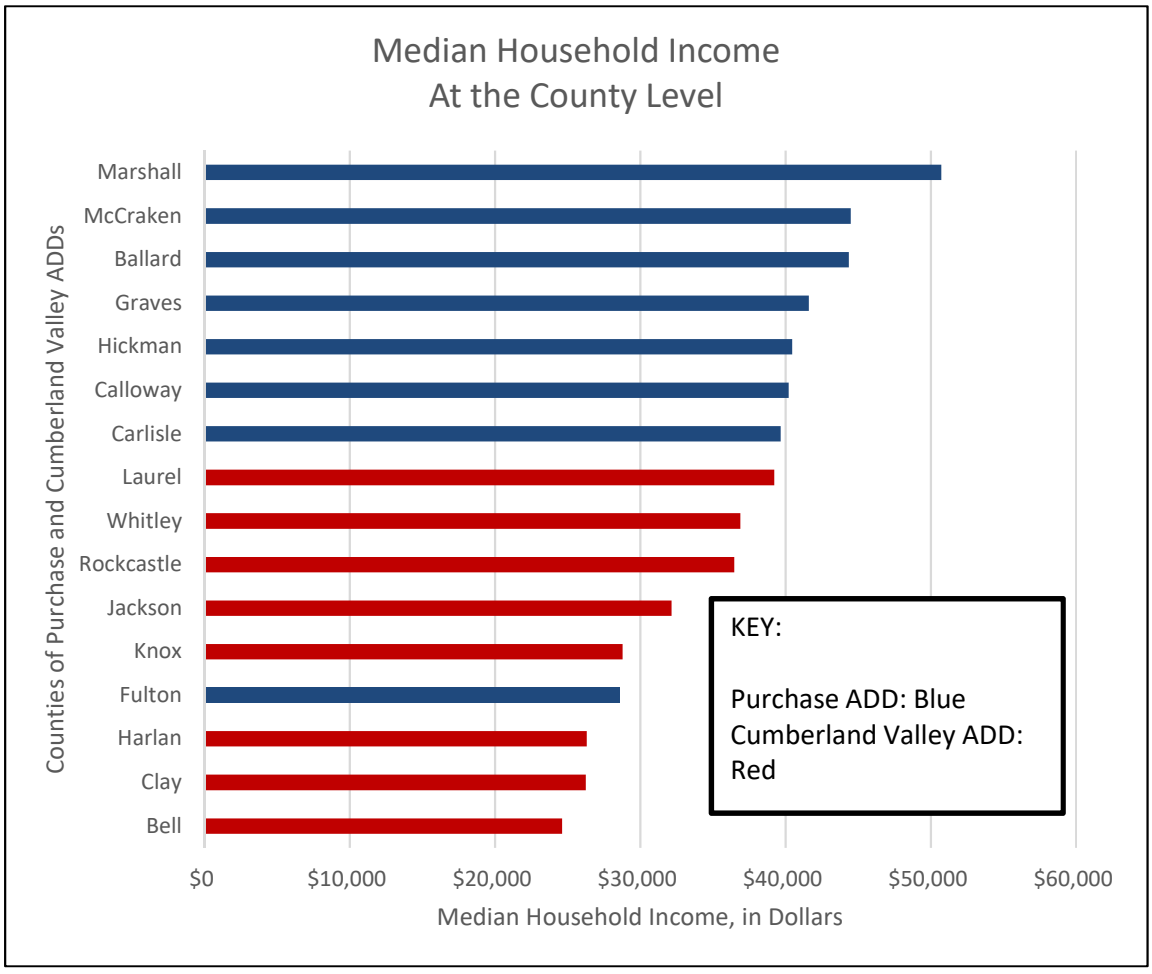

Figure 4 Median Household Income at County Level

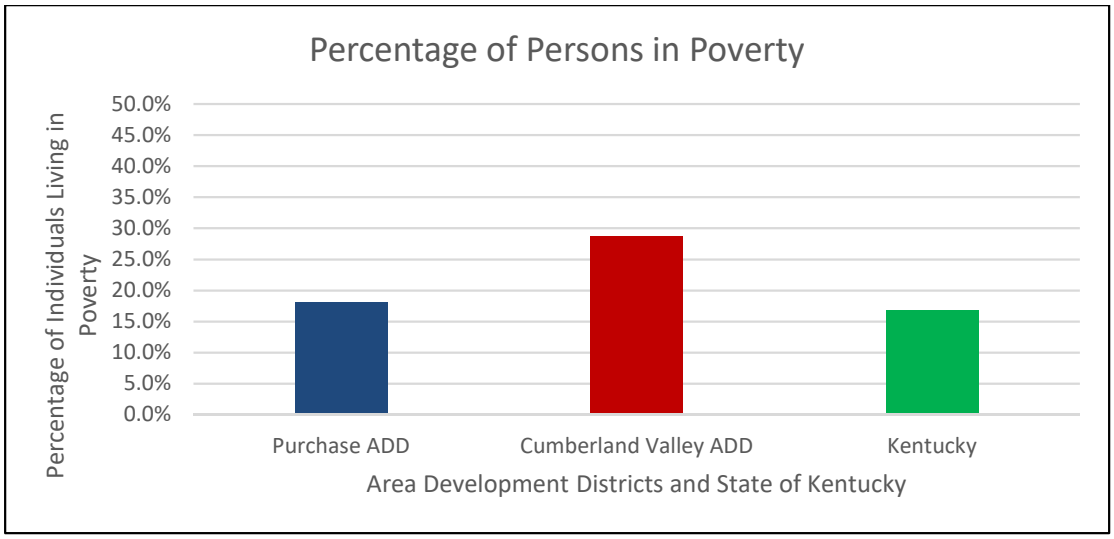

Figure 5 Percentage of Persons Living in Poverty in Purchase ADD, Cumberland Valley ADD, and State of Kentucky

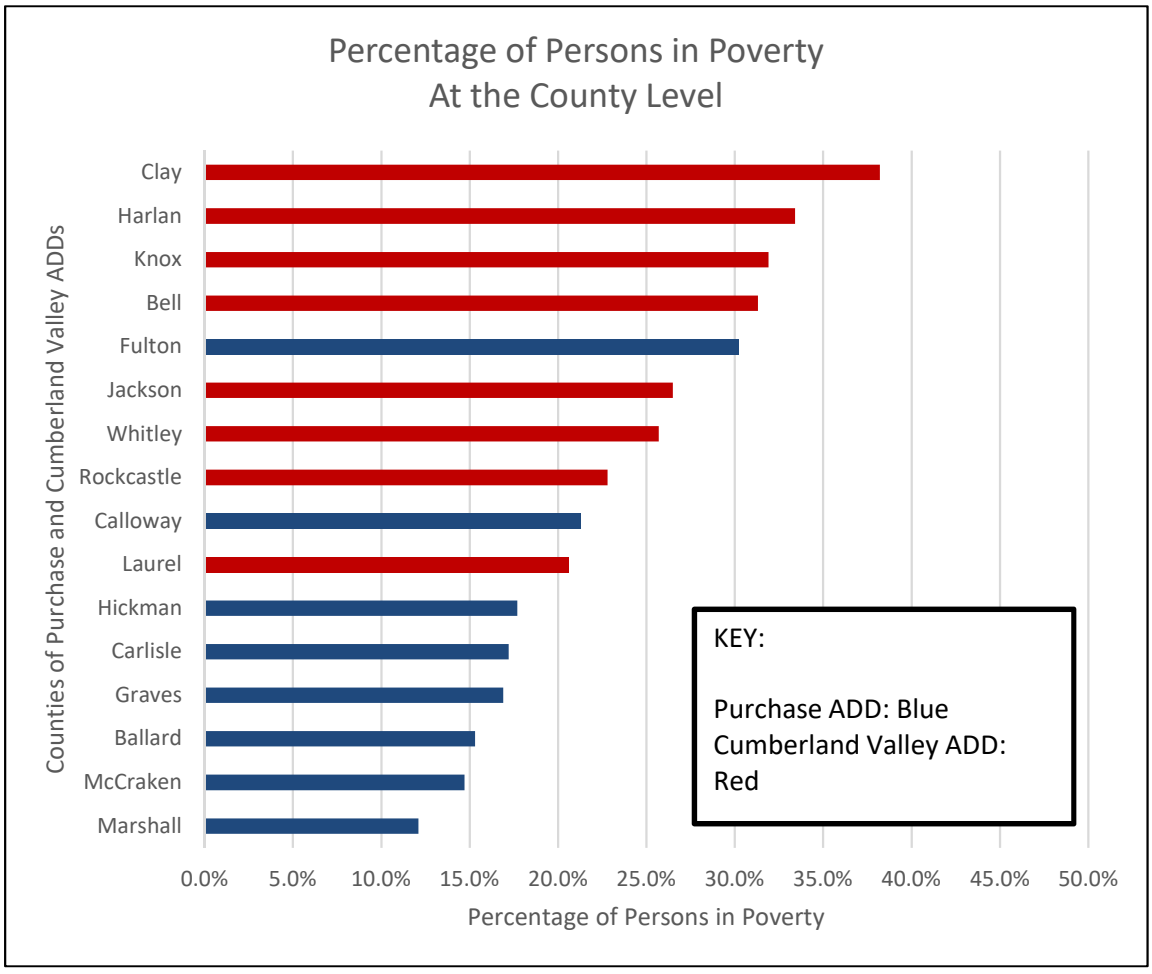

Figure 6 Percentage of Persons Living in Poverty at County Level

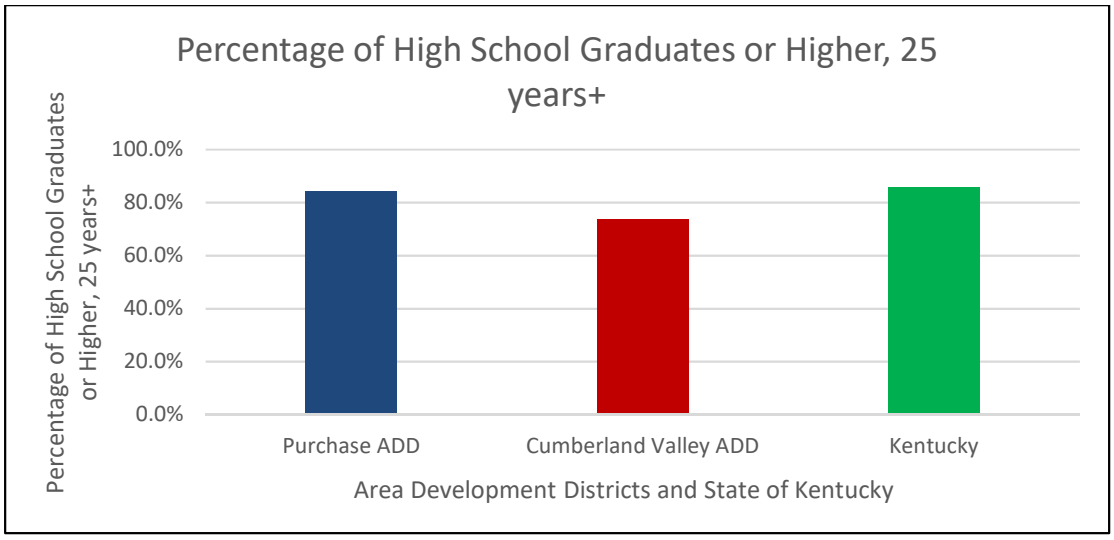

Figure 7 Percentage of High School Graduates or Higher in Purchase ADD, Cumberland Valley ADD, and State of Kentucky

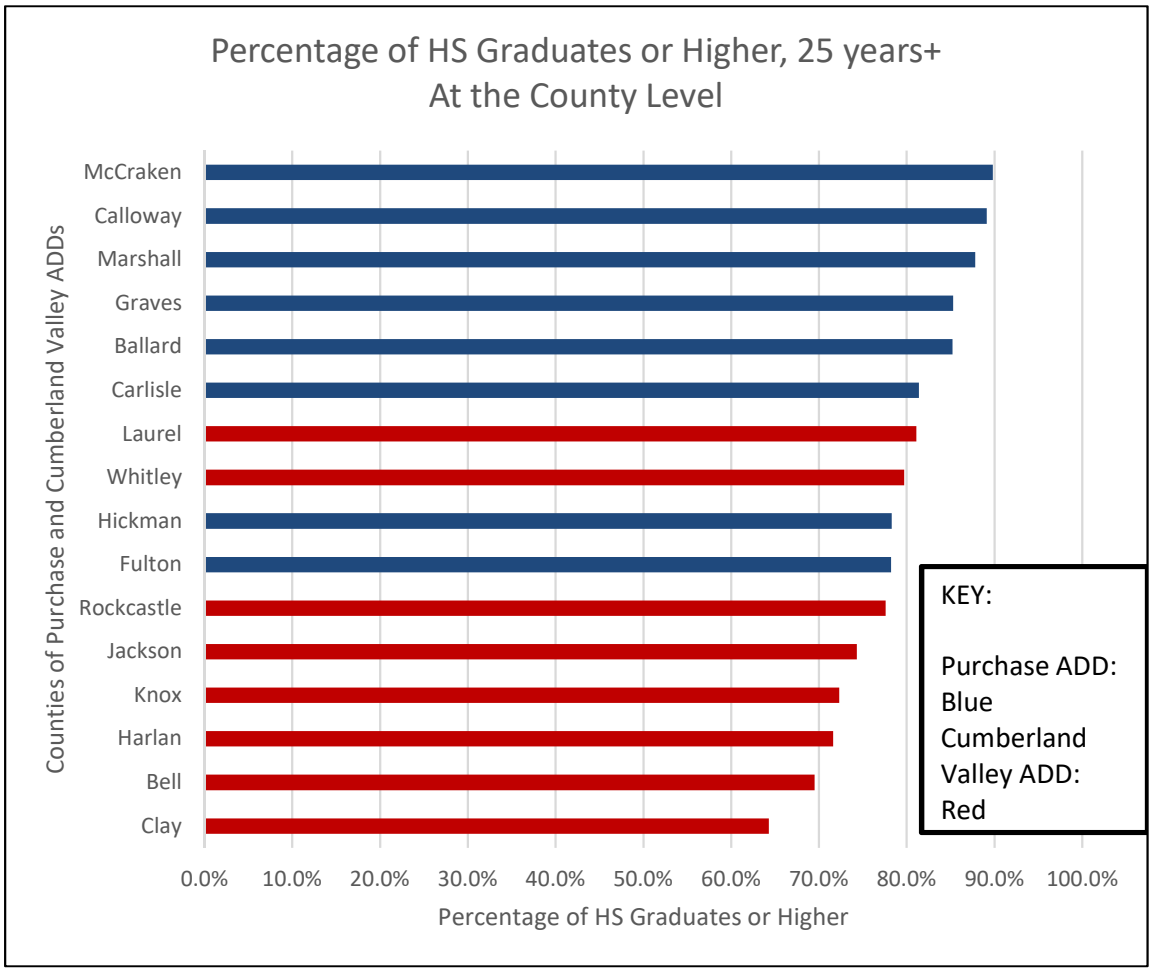

Figure 8 Percentage of High School Graduates or Higher at County Level

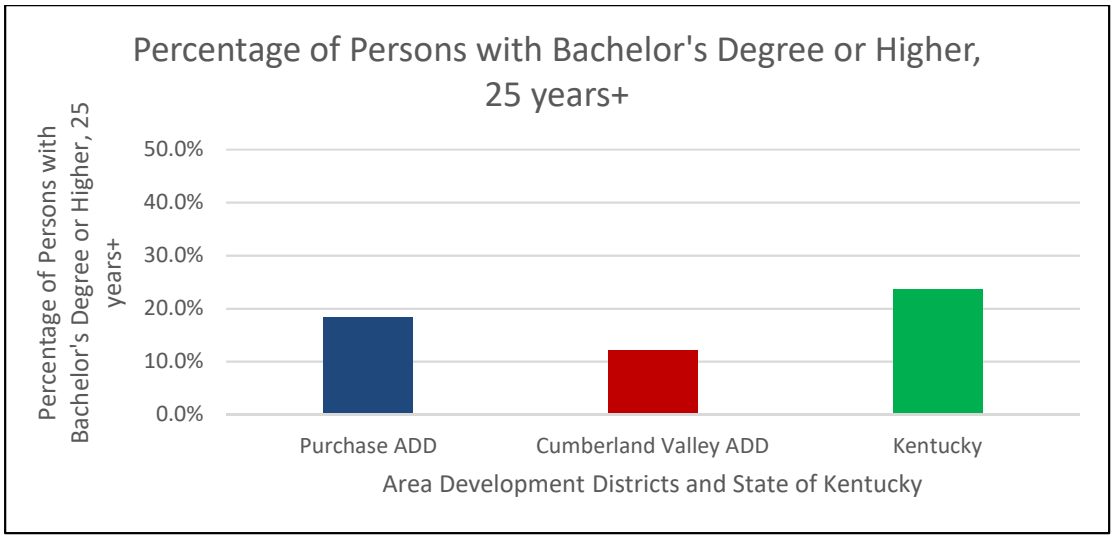

Figure 9 Percentage of Persons with Bachelor's Degree or Higher in Purchase ADD, Cumberland Valley ADD, and State of Kentucky

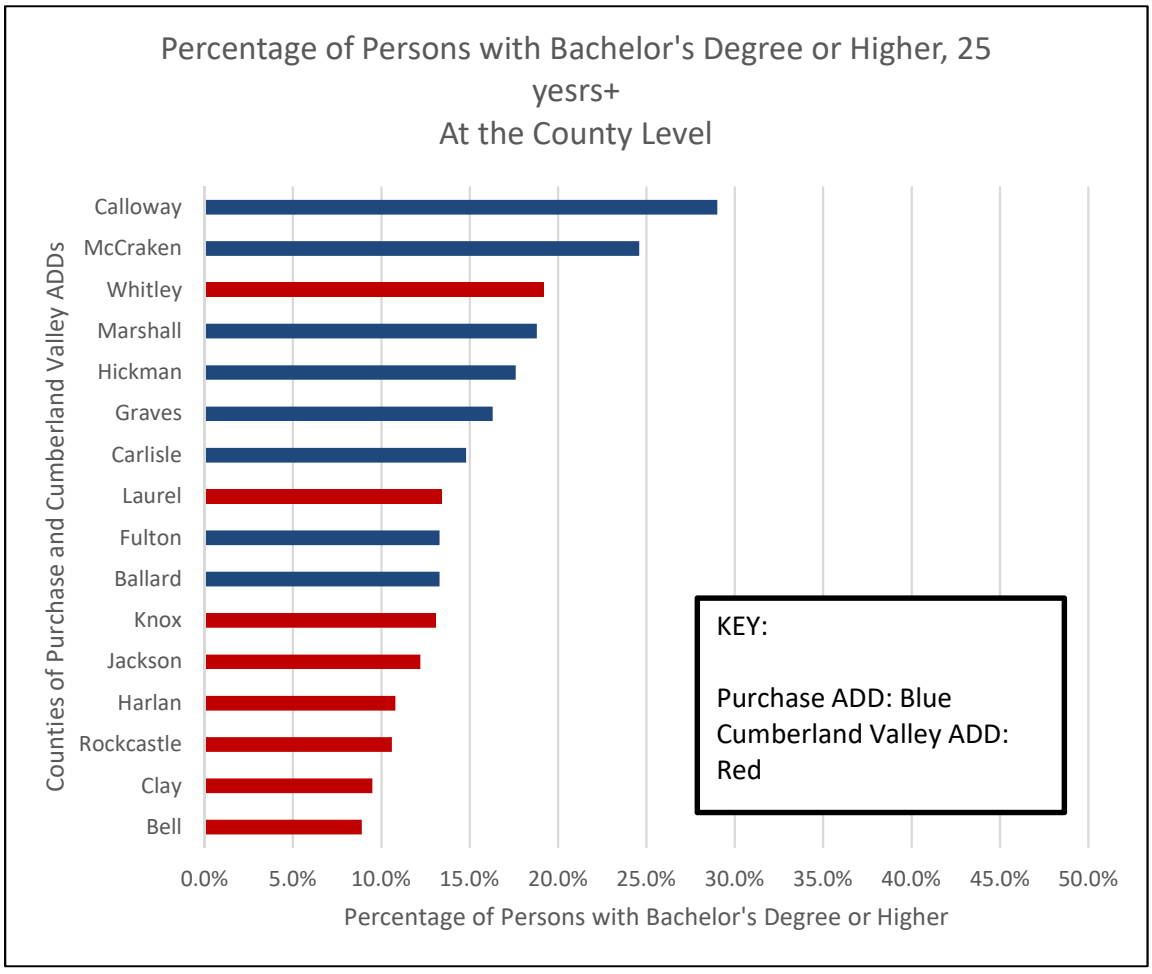

Figure 10 Percentage of Persons with Bachelor's Degree or Higher at County Level